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1.	Your Reference	P58923V-GB
2.	Patent Application number *(The Patent Office will fill in this part)*	0326061.9
3.	Full name, address and postcode of the or each applicant *(underline all surnames)*	The BOC Group plc Chertsey Road Windlesham Surrey GU20 6HJ
	Patents ADP Number *(if you know it)*	7975944001
	If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4.	Title of the invention	Improvements In Screw Pumps
5.	Name of your agent *(if you have one)*	FRY HEATH & SPENCE LLP
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	The Gables Massetts Road Horley Surrey RH6 7DQ United Kingdom
	Patents ADP Number *(if you know it)*	~~05889273881~~ 8459554001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or each of these earlier applications and *(if you know it)* the or each application number.			

		Number of earlier application	Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application.		

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* — Yes

a) *any applicant named in part 3 is not an inventor; or*
b) *there is an inventor who is not named as an*
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(See note (d))

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Description	6
Claim(s)	2
Abstract	1
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Priority documents	0
Translations of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
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Request for substantive examination *(Patents form 10/77)*	0
Any other documents *(please specify)*	0

11. I/We request the grant of a patent on the basis of this application.

Signature VJ Townsend

Date 10 November 2003

12. Name and daytime telephone number of person to contact in the United Kingdom: Victoria J Townsend - 01293 776880

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DUPLICATE

IMPROVEMENTS IN SCREW PUMPS

This invention relates to screw pumps, more specifically to screw pumps with tapered screw mechanisms and which are typically used in vacuum applications. The invention is directed to improvements in the operational efficiency of the aforementioned pumps.

Screw pumps are widely used in industrial processes to provide a clean and/or low pressure environment for the manufacture of products. Applications include the pharmaceutical and semi-conductor manufacturing industries. A typical screw pump mechanism comprises two spaced parallel shafts each carrying externally threaded rotors, the shafts being mounted in a pump body such that the threads of the rotors intermesh. Close tolerances between the rotor threads at the points of intermeshing and with the internal surface of the pump body (which acts as a stator), causes volumes of gas entering at an inlet to be trapped between the threads of the rotors and the internal surface and thereby urged towards an outlet of the pump as the rotors rotate.

Various adaptations of the basic screw pump mechanism are known, for example, there exist screw pumps with variable pitch screw threads and/or mechanisms wherein the height (or outside diameter) of the screw thread tapers decreasingly in a direction from the pump inlet to the exhaust of the pump. In the latter case, the rotors are mounted in a tapering bore of the stator.

It is desirable when operating a screw pump to achieve a desired pressure ("ultimate pressure") which is typically significantly below atmospheric pressure, that the input power needed to operate the pump is minimised. The size of the pump exhaust volume has a considerable effect on the input power needed to operate a pump at ultimate pressure. The input power can be maintained low by inbuilding a high volume ratio between the inlet volume and the exhaust volume of the pump. A

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disadvantage of this arrangement is that as the inlet pressure of the pump increases towards atmospheric pressure, there is a significant increase in the input power requirements of the pump.

In the prior art, high pump inlet pressures have been avoided by inclusion of a blow-off valve within the pump which can be activated to release pressure and prevent build up of excessive pressure in the pump. In some situations, the performance of these valves can be adversely affected by build up of process media on or near sealing surfaces, reducing the efficiency with which pressure build up can be relieved.

The present invention aims to provide an alternative and more reliable means for reducing the power input requirements of a screw pump.

In accordance with the present invention, there is provided a screw pump comprising a pair of rotors each carrying an external screw thread, the pair of rotors rotatably mounted in a stator by rotatably mounting means and arranged such that, in operation, the screw threads of the rotors intermesh as the rotors rotate in opposing directions and characterised by means for effecting or resisting axial movement of the rotors in response to an axial load generated in the rotors during operation of the pump.

When in operation, internal pressure within a pump produces an axial thrust load in the rotor, this thrust load is proportional to the amount of gas compression work being performed by the pump and hence the input power requirements of the pump. The efficiency of gas compression of a screw pump is, to a large extent dictated by the clearance between the internal surface of the stator which carries the screw threaded rotors and the rotors themselves. Where the rotors are tapered, they may be moved both simultaneously and synchronously away from the stator face effectively increasing the radial clearance, reducing the compression and hence the power input requirements.

The means for rotatably mounting the rotors in the stator may conveniently comprise rotary bearings which carry a shaft extending from or passing through a rotor. The means for effecting or resisting axial movement may include a housing in which the rotary bearings are free to move in an axial direction and a spring mechanism arranged with respect to the rotor such that, when the rotor is subjected to an axial load, the spring mechanism compresses or extends causing an axial reactive load in the rotor. For example, the spring mechanism may comprise a setting spring positioned in a housing between rotary bearings of the rotatably mounting means and an end surface of the housing. When an axial load generated in a rotor tends to cause axial displacement of the rotor and bearing assembly, the spring may be compressed or extended (depending on its position). Assuming the load does not exceed the elastic limit of the spring, the spring will react to vary the axial position of the rotor. By selecting a spring with a suitable spring constant, the arrangement can be used to vary the rotor/stator clearance giving a relatively constant level of gas compression work over a wide range of inlet pressures, thereby moderating the power input requirements of the pump.

As an alternative to a spring type mechanism, a piston arrangement may be employed, the piston arrangement being actuated by a control device which is responsive to the input power and resulting axial load to cause the piston to actuate so as to reposition or maintain position of the rotor. The control device may also be used actively to move the rotors closer to the stator surface with the rotors in operation to scrape off process media build up on the stator surface.

Optionally, the means for effecting axial movement for each rotor are connected so as to ensure both rotors are maintained in the same axial position.

In another option, the means for effecting or resisting axial movement may be configured so as to permit relative axial movement between the rotors, typically such relative movement will be within the limits of rotor contact and might be used with the rotors in operation to scrape off process media build up on the flanks of the screw threads of the rotors. The latter can be achieved using independent means for effecting or resisting axial movement on each rotor, for example the piston arrangement previously mentioned. An associated control device may be configured to actuate the pistons independently of one another.

For the purposes of exemplification, some embodiments of the invention will now be further described with reference to the following Figures in which:

Figure 1 to 4 show a first embodiment of a screw pump in accordance with the invention in four different views.

Figures 5 to 7 show in more detail, the means for effecting axial movement of the rotors in the embodiment of Figure 1

Figures 2 and 3 show respectively side and top views of a screw pump of the invention. Figure 1 shows a section through the plane B-B marked in Figure 2 and Figure 4 shows a section through the plane A-A marked in Figure 3.

Many of the components of the screw pump of the invention are known from the prior art, these include the stator, the pair of screw threaded rotors 2a, 2b, the drive mechanism 3 and motor 4 which powers the drive mechanism 3, and the bearings 5a, 5b by means of which the shafts of the rotors 2a, 2b are rotatably mounted.

The novel features include the arrangement of angular bearings 6a, 6b, slidably mounted in cylinder housings 7a, 7b and the springs 8a, 8b sited between the angular bearing arrangements 6a, 6b and an end surface of the cylinder housings 7a, 7b. The cylinder housings 7a and 7b are fastened to the rotors 2a, 2b and are connected to each other by connecting arm 9. The arrangement of the novel features are shown more clearly in Figures 5 to 7.

As can be seen from Figures 5 to 7, the means for rotatably mounting the rotors and means for effecting or resisting axial movement include a pair of angular contact bearings 6', 6" arranged in a back to back configuration to maintain the lateral position of the rotors 2a, 2b with respect to the stator 1 whilst allowing axial movement of the rotor shaft passing through the bearings and rotation of the rotor shaft about its longitudinal axis. The bearings 6', 6" are housed in the cylindrical housing 7. A small clearance is provided between the bearings 6', 6" and the inner, circular surface of cylinder 7. The cylinder housing 7 has a small radial clearance with the stator body which allows the whole assembly to be moved back and forward to fix the initial radial clearance in the pump during build. This is achieved by placing shear material between the stator body and the clamping flange 10.

The bearings 6', 6" can be assembled into the cartridge 14 together with a spacer ring 13 and a spring 8 and clamped such that the preload on the spring 8 can be set for the running load condition (and input power of the pump) that the rotors 2a, 2b are required to move to increase the radial gap between the rotor and stator. A front face 11 of the cylindrical housing 7 extends radially inwardly towards the collar 12 which forms part of an assembly for fastening the cylindrical housing 7 to the shaft of a rotor 2a or 2b. The spring 8 is contained by the spacer ring 13 positioned between the spring 8 and bearing assembly 6', 6". A flange 10 is provided at the rear end of the cylindrical housing 7 on to which is bolted a

connector arm 9 which, in use, may be secured to a similar assembly of parts associated with a second rotor. The assembly is positioned at the outlet end of the pump.

In use compression work done by the pump results in an axial load tending to move the rotors in a direction from the outlet towards the inlet. Where there is any difference in axial load on the two rotors, the connector 9 ensures both rotors are repositioned simultaneously, avoiding any interference which may occur between the rotors should they become misaligned with respect to each other.

In a variation of the embodiment of Figures 1 to 7, in place of the spring mechanism 8 and cylindrical housing 7 there may be provided pneumatically controlled pistons. Movement of the pistons may be controlled by a controller which may include a force sensor which detects the axial load on a given rotor axis and causes a reactive force to be applied by means of the pistons. In addition, the controller may be configured to allow independent movement of the pistons and hence the rotors for other purposes, for example rotor cleaning.

CLAIMS

1. A screw pump comprising a pair of rotors each carrying an external screw thread, the pair of rotors rotatably mounted in a stator and arranged such that, in operation, the screw threads of the rotors intermesh as the rotors rotate in opposing directions and characterised by means for effecting or resisting axial movement of the rotors in response to an axial load generated in the rotors during operation of the pump.

2. A screw pump as claimed in claim 1 wherein the means for rotatably mounting the rotors in the stator comprise rotary bearings which carry a shaft extending from or passing through a rotor and the means for effecting or resisting axial movement include a housing in which the rotary bearings are free to move in an axial direction and a spring mechanism arranged with respect to a rotor such that when the rotor is subjected to an axial load, the spring mechanism compresses or extends causing an axial reactive load, whereby to maintain a constant axial position of the rotor over time.

3. A screw pump as claimed in claim 2 wherein the spring mechanism comprises a setting spring positioned in a housing between rotary bearings of the rotatably mounting means and an end surface of the housing.

4. A screw pump as claimed in claim 2 or 3 wherein the housing is a cylindrical housing having an end surface extending radially inwardly toward the rotor.

5. A screw pump as claimed in any of claims 2 to 4 wherein the spring mechanism is selected such that the maximum axial load to which a

rotor is likely to be subjected does not exceed the elastic limit of the spring mechanism.

6. A screw pump as claimed in claim 1 wherein the means for effecting or resisting axial movement include a piston actuatable by a control device which control device is responsive to an input power and resulting axial load on a rotor to cause the piston to actuate so as to reposition or maintain axial position of the rotor.

7. A screw pump as claimed in any preceding claims wherein the means for effecting or resisting axial movement for each rotor are connected to one another so as to ensure both rotors are maintained in the same axial position.

8. A screw pump as claimed in any of claims 1 to 6 wherein the means for effecting or resisting axial movement for each rotor are operable independently to allow non-synchronous as well as synchronous axial displacement of the rotors.

9. A screw pump as claimed in any preceding claim wherein the screw threads of the rotors have an outside diameter which tapers decreasingly in a direction from the pump inlet to the exhaust of the pump.

10. A screw pump substantially as described herein and with reference to the accompanying Figures 1 to 7.

ABSTRACT

IMPROVEMENTS IN SCREW PUMPS

A screw pump comprising a pair of rotors 2a, 2b each carrying an external screw thread, the pair of rotors rotatably mounted in a stator 1 and arranged such that, in operation, the screw threads of the rotors intermesh as the rotors rotate in opposing directions and characterised by means 7a, 8a, 7b, 8b for effecting axial movement of the rotors 2a, 2b in response to an axial load generated in the rotors during operation of the pump. The means for effecting axial movement may, for example, comprise a spring mechanism or piston device configured and arranged to react to an axial load in a rotor to resist axial movement of the rotor.

[Fig. 1]

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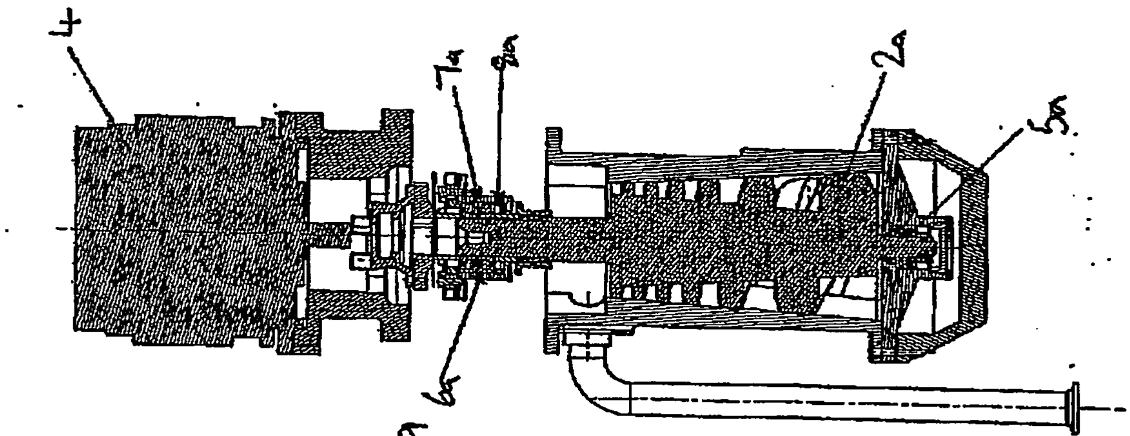

Fig. 4

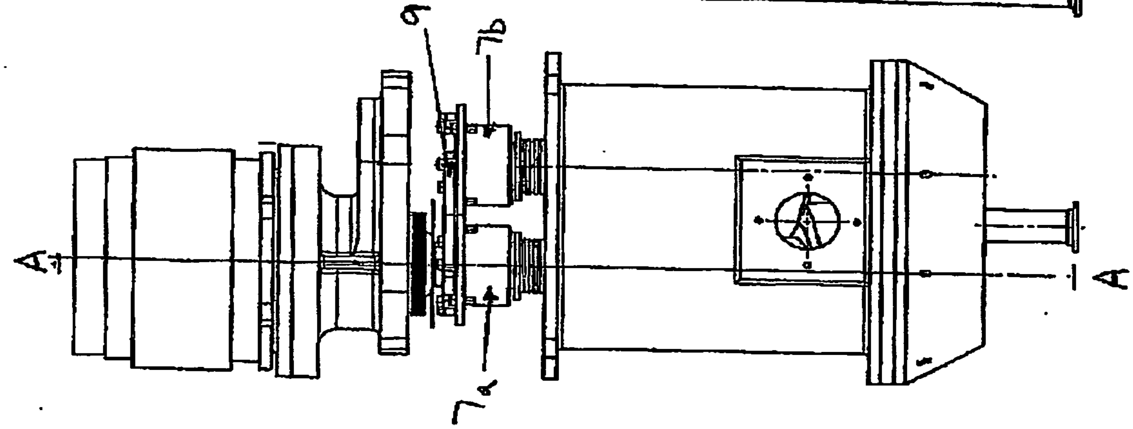

Fig. 3

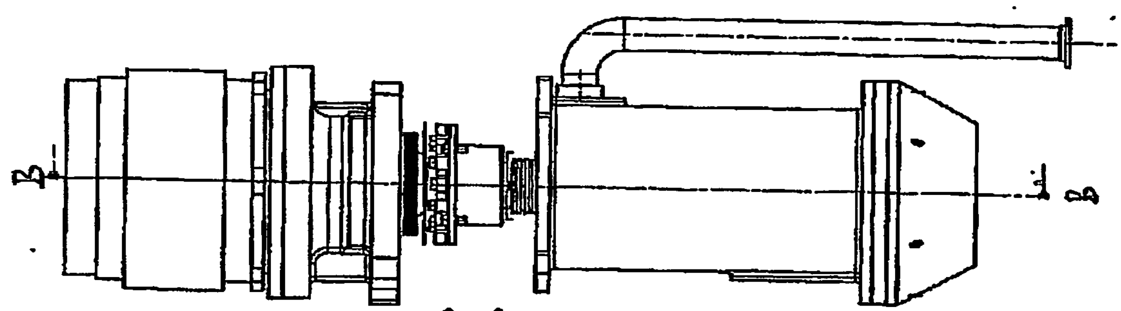

Fig. 2

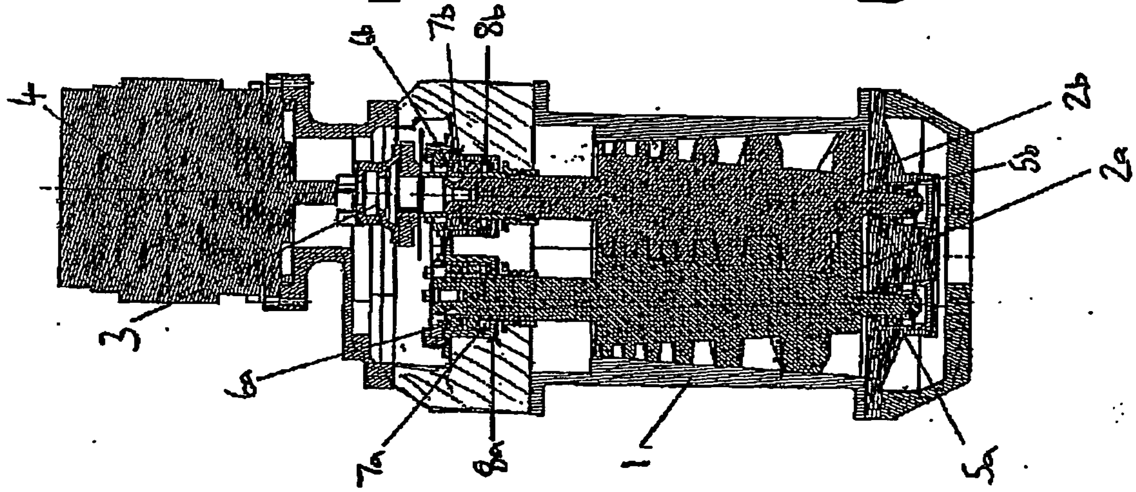

Fig. 1

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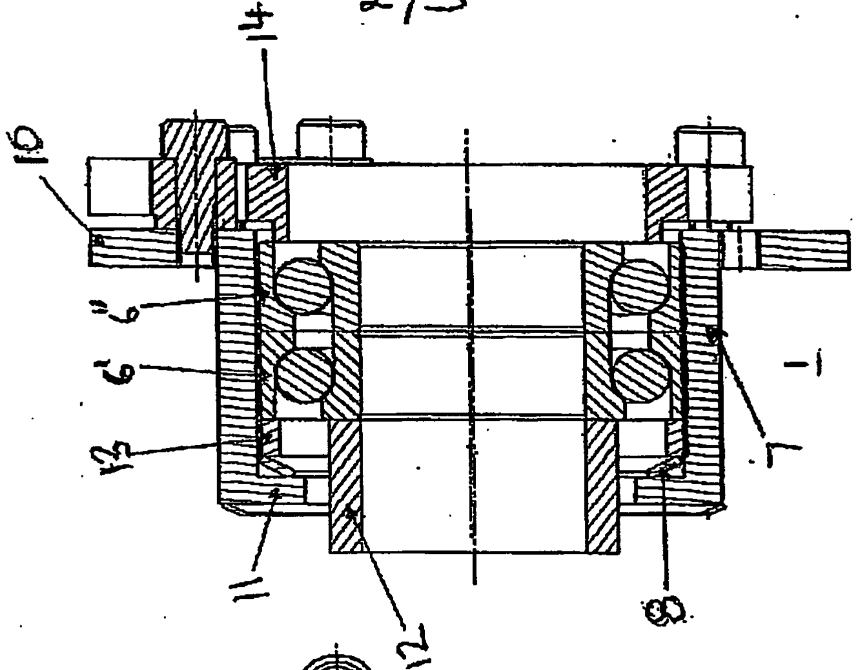

Fig.6

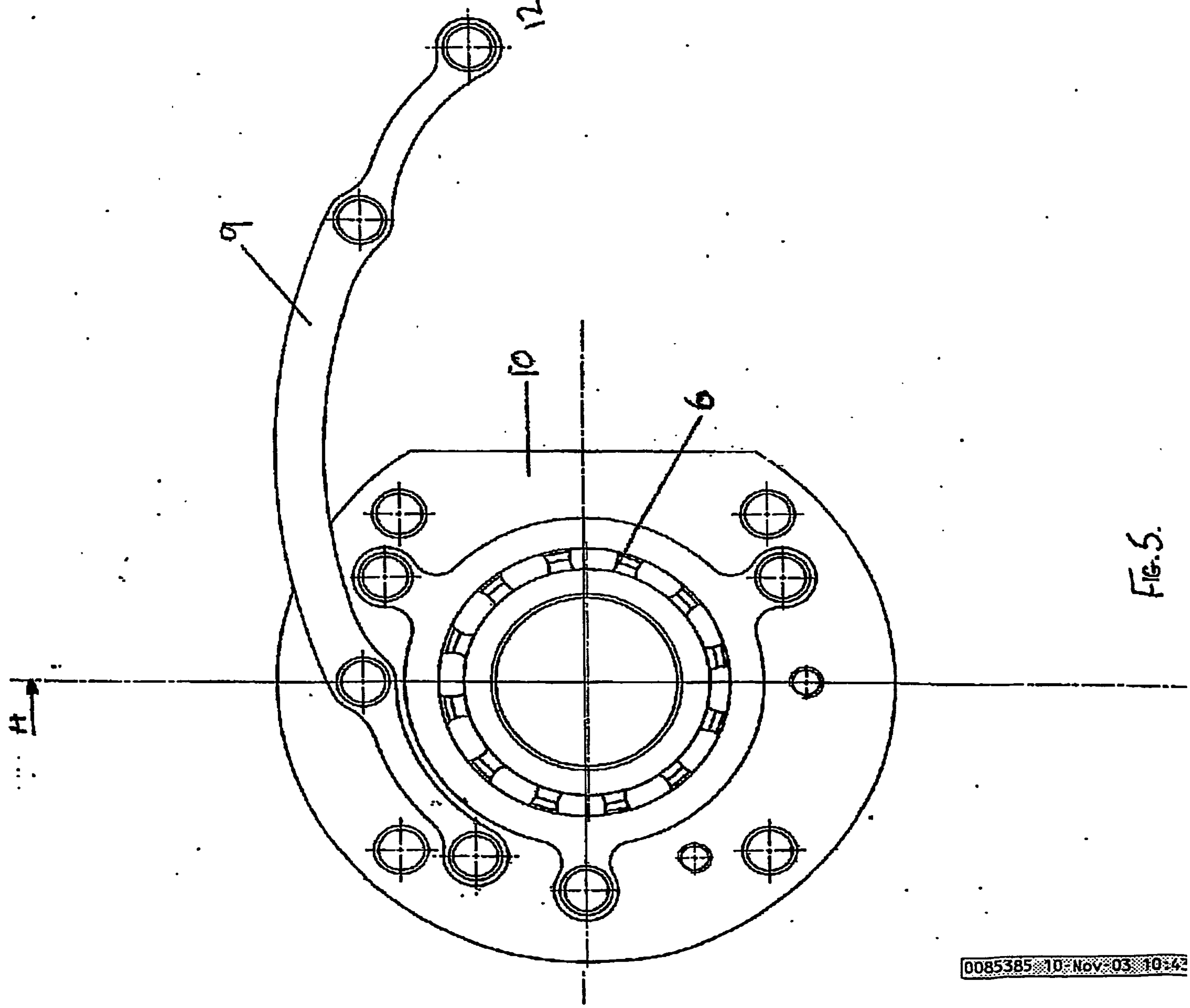

Fig.5.

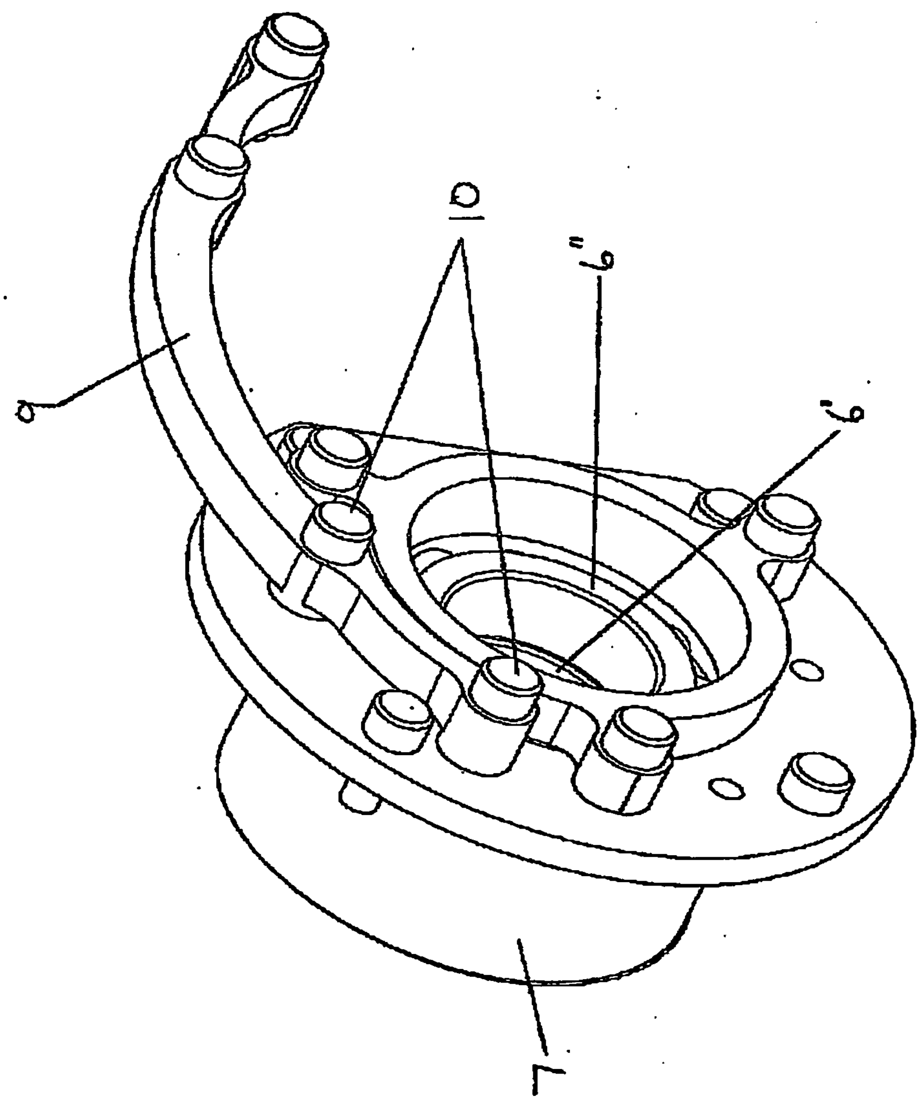

FIG. 7

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